

Application Note

The TEA1064A with complex set impedance and complex line termination

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Summary:

More and more PTTs require a complex set impedance for telephone sets. It can be expected that the sending frequency curves will be measured with a complex line termination instead of 600Ω . The German PTT is the first one that actually changed over from 600Ω to a complex termination. Furthermore they require a better accuracy of the complex set impedance (balance return loss up to 18dB). To prevent high frequency roll-off in sending direction with the TEA1064A in such a case, the application hint mentioned in this report should be considered.

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1. Introduction

In the early days of electronic telephone sets PTT requirements were based upon the classical telephone sets. The AC impedance of such a set was 600Ω, a figure based upon the average characteristic impedance of the lines used (air cables). The allowed variation on this impedance is expressed as Balance Return Loss (BRL):

$$BRL = 20 \cdot \log \left| \frac{Z_{set} + Z_{ref}}{Z_{set} - Z_{ref}} \right| \quad \text{with } Z_{ref} = 600\Omega$$

Requirements nowadays vary from 6dB (USA) up to 18dB (Germany)

Over the last couple of years more and more PTT's switch over to the requirement of complex impedances for telephone sets, because of better line termination (ground cables).

Examples:

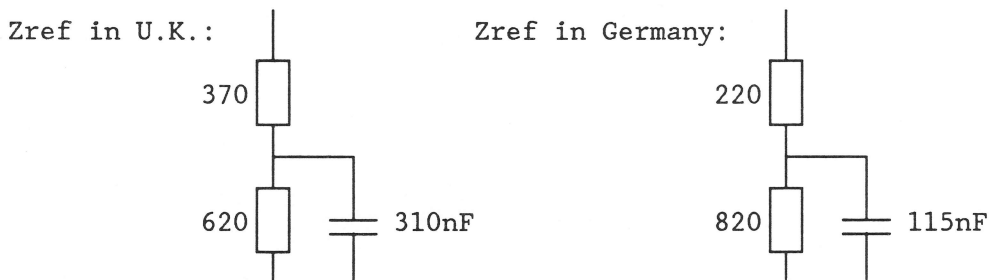


Figure 1: Complex reference impedances for UK and Germany

When using the TEA1064A with complex set impedance high frequency roll off (above ≈1500Hz) in sending direction occurs. This is caused by the sending amplifier configuration. Up to now however, most countries measure the sending gain curves with a 600Ω line termination. In this way the influence of the complex set impedance on the sending characteristics is smoothed (600Ω//Zset). In practice therefore, in most cases a compromise has to be made between set impedance and sending frequency curves in order to fulfill requirements.

Recently however, for instance the German PTT decided to measure the sending characteristics with the line terminated with Zref. Besides that, BRL figures have been increased up to 18dB in the frequency range of 500-2500Hz. These two new requirements make it impossible to compromise between BRL and frequency roll-off (Zset//Zref). Total roll-off within the audio band (300-3400Hz) will be up to 6dB! It can be expected that other PTT's will follow the German requirements in future.

This report describes an application hint for the TEA1064A to obtain a high balance return loss (with complex Zref) and a nearly flat frequency response (with complex termination).

set impedance too much. In such a case the value of Leq ($Leq = R_p \cdot R_1 \cdot C_3$) can be increased by increasing C_3 (at pin REG) or R_9 (at pin SLPE). It should be noted however, that changing R_9 will also change other transmission parameters (e.g. sending gain, sidetone, AGC, etc.) while the DC start-up time is proportional to the value of C_3 .

SIDETONE:

The impedance between LN and VCC1 is a part of the anti sidetone bridge (2 to 4 wire conversion). If R_1 is changed from the original value (figure 2) sidetone attenuation changes. For calculating the new bridge balance please refer to reference 1.

SUPPLY POINT VCC1:

The supply point VCC1 is used to supply the internal circuitry. This voltage is obtained from the line via the impedance between LN and VCC1 ($\approx$ set impedance) and smoothed by a big capacitor (figure 2). Since a complex impedance usually has a higher DC resistance ($\approx 1k\Omega$) compared to the standard 600Ω resistor, voltage VCC1 will be lower. For correct operation it can be necessary to increase the reference voltage of the TEA1064A by means of resistor R_{17} (see also figure 2). For more details refer to reference 1.

3. Frequency compensation in sending direction

The gain of the microphone amplifier, between LN and the microphone inputs of the TEA1064A, is given by the following equation (see also reference 1):

$$A_m = 1.356 * \frac{R_{GS}}{R_5 * R_9} * R_{LN} \quad (1)$$

In which: R_{GS} = impedance between GAS1 and SLPE
 R_5 = 3.65k Ω resistor connected to STAB
 R_9 = resistor connected to SLPE
 R_{LN} = impedance seen at pin LN

In case of a complex set impedance and a complex line termination the load at LN will not be constant with frequency. The absolute impedance decreases above approximately 1500Hz, thus within the speech band (300-3400Hz). For equation (1) this means that the microphone gain will decrease! In order to compensate for this effect the network between GAS1 and GAS2, as shown in figure 4, can be used:

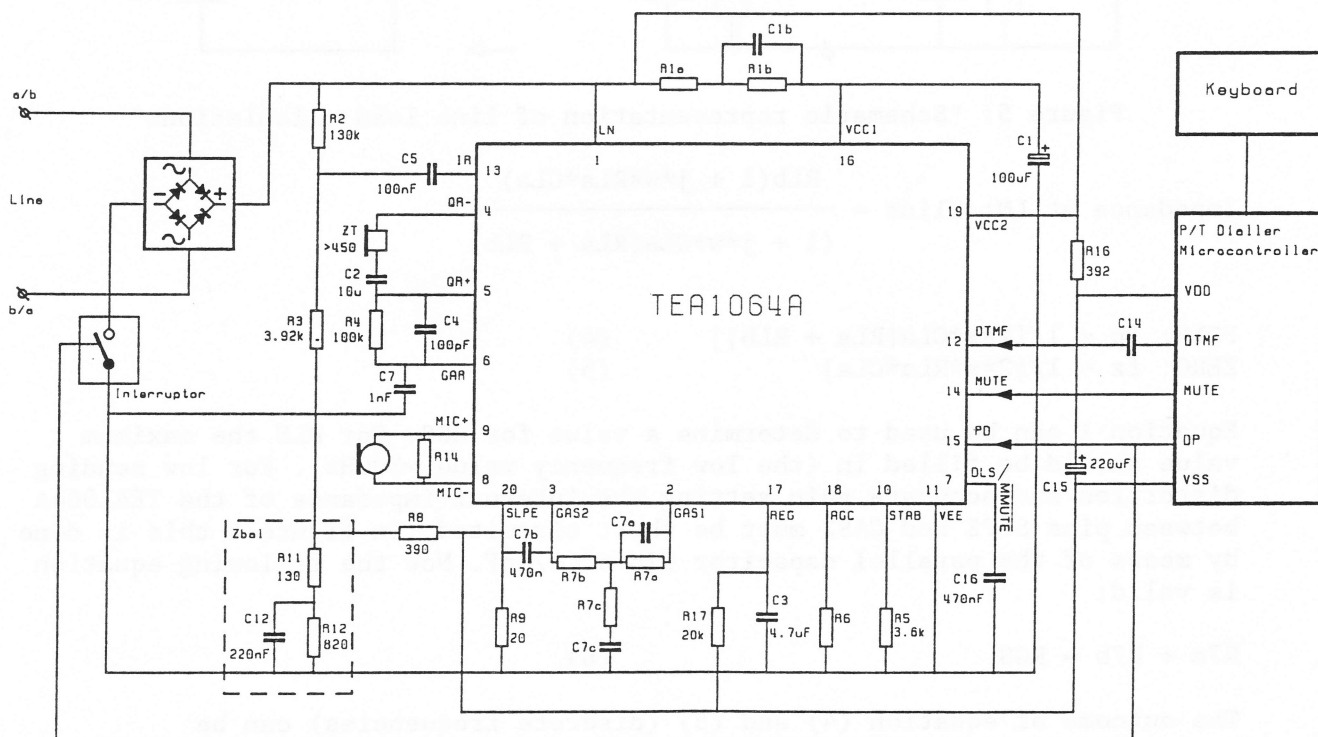


Figure 4 "TEA1064A application with complex set impedance"

With this network a pre-emphasis is created in the sending amplifier:

$$\text{ZERO: } f_z = 1/[2\pi \cdot C7c \{ (R7a/R7b) + R7c \}] \quad (2)$$

$$\text{POLE: } f_p = 1/[2\pi \cdot C7c \cdot R7c] \quad (3)$$

The pole and the zero should eliminate respectively the zero and the pole occurring at the line due to the complex load.

In order to calculate the optimum values for the components of this network the exact load at LN needs to be determined. For correct calculation of this load the internal impedance of the TEA1064A (15.5kΩ) has to be included. If also other components are connected to the line (e.g. EMC capacitor) they should be included in the calculations as well.

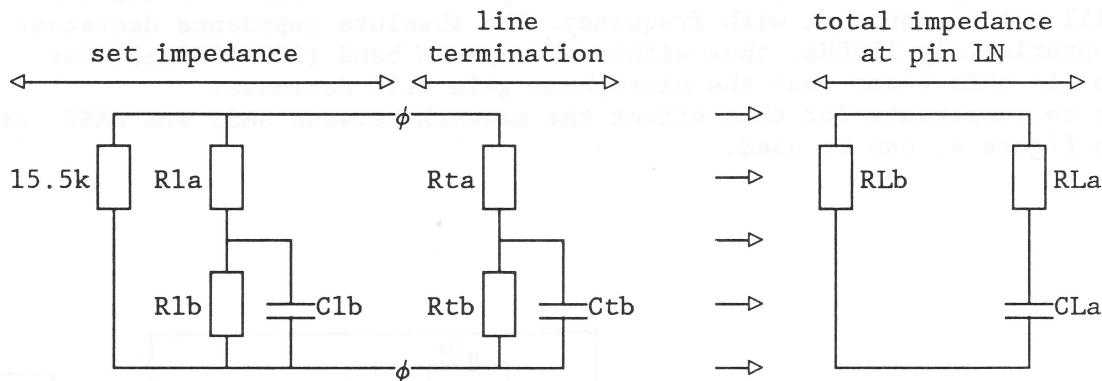


Figure 5: "Schematic representation of line load calculations"

$$\text{Impedance at LN: } Z_{\text{line}} = \frac{RLb(1 + j\omega \cdot RLa \cdot CLa)}{(1 + j\omega \cdot CLa(RLa + RLb))}$$

$$\text{POLE: } f_p = 1/[2\pi \cdot CLa \{ RLa + RLb \}] \quad (4)$$

$$\text{ZERO: } f_z = 1/[2\pi \cdot RLa \cdot CLa] \quad (5)$$

Equation 1 can be used to determine a value for RGS. For RLN the maximum value should be filled in (the low frequency value ≈300Hz). For low sending distortion and accurate gain setting the internal impedance of the TEA1064A between pins SLPE and GAS2 must be short circuited. In figure 4 this is done by means of the parallel capacitor C7b of 470nF. Now the following equation is valid:

$$R7a + R7b = RGS \quad (6)$$

The outcome of equation (4) and (5) (discrete frequencies) can be substituted in (2) and (3) respectively. Together with equation (6), 3 equations are left with 4 unknown parameters. By picking one parameter (e.g. R7a=R7b or a value from the E12 series for capacitor C7c) the others can be calculated.

For stability reasons a capacitor must be connected in parallel with R7a, which can also be used to create a first order roll-off. The minimum value

of this capacitor is determined by the maximum cut-off frequency of about 20kHz:

$$1/[2\pi \cdot C7a \cdot R7a] < 20\text{kHz}$$

Example:

In Germany the complex set impedance and complex line termination are equal: $220 + 820j/115\text{nF}$. For calculating the total load at the line the $15.5\text{k}\Omega$ internal TEA1064A resistor needs to be incorporated. We obtain (see also figure 5):

$$\begin{aligned} R_{Lb} &= 500\Omega \\ R_{La} &= 140\Omega \\ C_{La} &= 143\text{nF} \end{aligned}$$

with equation (4): $f_p = 1740\text{Hz}$

with equation (5): $f_z = 7950\text{Hz}$

Filling in these values in equations (2) and (3) respectively:

$$1/[2\pi \cdot C7c \cdot \{(R7a/R7b) + R7c\}] = 1740 \quad (\text{I})$$

$$1/[2\pi \cdot C7c \cdot R7c] = 7950 \quad (\text{II})$$

For the microphone gain 44.5dB ($168\times$) can be chosen as an example, with $R_9 = 39\Omega$ and $R_5 = 3.65\text{k}\Omega$ we obtain from equation (1):

$$A_m = (1.356 \cdot R_{GS} \cdot R_{LN}) / (3.65\text{k}\Omega \cdot 39\Omega)$$

For R_{LN} the low frequency value of the line load has to be taken which is 500Ω , together with equation (6) we now obtain:

$$R_{GS} = R7a + R7b = 35.3\text{k}\Omega \quad (\text{III})$$

Choosing

$$C7c = 10\text{nF}$$

with (II) we obtain

$$R7c = 2\text{k}\Omega$$

combined with (I) and (III):

$$R7a = 25.4\text{k}\Omega, \text{ practical } R7a = 25.5\text{k}\Omega$$

$$R7b = 9.9\text{k}\Omega, \text{ practical } R7b = 10\text{k}\Omega$$

A practical value for $C7a$ could be 470pF resulting in high frequency roll-off during sending at $f_{-3\text{dB}} = 13.3\text{kHz}$.

Ripple

Ripple can be caused by mismatch between the pre-emphasis curve (pole and zero) and the frequency roll-off caused by the complex load at LN. The allowable sending ripple in the audio band determines the allowable tolerances of the resistors and capacitors for the GAS1-GAS2 network. Since in practice 1% resistors can be used the ripple is mainly determined by capacitor tolerances (in practice 5% or 10%). At 10% capacitor tolerance 0.8dB maximum ripple can be expected, at 5% tolerance 0.4dB ripple can occur.

4. Conclusions

In countries where a complex set impedance is required and sending characteristics are measured with a complex line termination, the standard TEA1064A application does not satisfy. This is mainly due to high frequency roll-off within the speech band (300Hz - 3400Hz).

The TEA1064A application hint, mentioned in this report, makes it possible to obtain high balance return loss figures with complex set impedances. Besides, the sending frequency characteristic remains flat even with complex line terminations. For this purpose the number of components for the standard application extends with only 2 ceramic capacitors and 2 resistors.

5. References:

1. Philips Laboratory Report ETT89009; Application of the Versatile Speech/Transmission Circuit TEA1064 in full Electronic Telephone Sets; by F. van Dongen and P.J.M. Sijbers.

Relevant literature:

2. Philips Laboratory Report ETT8802; Application Proposal for the German Market of the TEA1064 Electronic Speech Transmission Circuit; by K. Wortel

3. Philips Laboratory report ETT/AN90001; Documentation for TEA1064A printed circuit board CAB3458; by P. Biermans, P. Sijbers and K. Wortel

4. TEA1064A datasheet

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